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ADVANCED SURVEILLANCE TESTBED (AST) SPACE BASED INFRARED UPGRADES

General Research Corporation

R. Chase and K. Singkofer

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Rome Laboratory
Air Force Materiel Command
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APPROVED: James J. Maier

JAMES J. MAIER
Project Engineer

FOR THE COMMANDER: Joseph Camera

JOSEPH CAMERA
Technical Director
Intelligence & Reconnaissance Directorate

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6. AUTHOR(S)
R. Chase and K. Singkofer

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
General Research Corporation
31255 Cedar Valley Drive, Suite 300
Westlake Village CA 91362

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Rome Laboratory/IRAE
32 Hangar Rd
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This report covers upgrades made to the General Research Corporation Advanced Surveillance Testbed (AST). Under this task, major upgrades were made to the AST phenomenological models. These included upgrades to the synthetic background models, development of a statistical persistence model, and development of a target intensity model based on CHARM and SIRRM. In addition, selected AST signal processing and data processing modules were upgraded to accommodate the newly defined phenomenological inputs.

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1. Introduction

This Final Report (CDRL S005) covers the Subcontract 0277-3003482 to General Research Corporation from Harris Corporation. The contract is under the Rome Laboratories IRA TOA Program, Task 41 "Advanced Surveillance Testbed Space Based Infrared Upgrades".

This task was initiated on 02 Mar 94 and technical work was concluded 01 Feb 95. Final Documentation preparation and submittal continued through 31 Mar 95.

In addition to this Final Report CDRL S005, two other major documents were prepared that describe the results of the work under this contract. These reports are: 1) **The Advanced Surveillance Testbed - Detailed Description Document - Version 5** (CDRL S004), submitted 14 Dec 94, and 2) **Final Briefing - Rome Labs / Harris IRA TOA Task 41 - AST Space Based Infrared Upgrades** (CDRL S003), submitted 14 Dec 94. These reports are Space Based Early Warning System (SBEWS) Competition Sensitive, and as such are subject to limited distribution. Distribution has been limited to Government personnel only at the SBEWS SPO at the Space and Missile System Center in El Segundo, CA, and to Rome Laboratories / IRAE.

This final report summarizes the work performed under this contract and does not contain any SBEWS Competition Sensitive information.

2. Advanced Surveillance Testbed Overview

The AST has been evolving at GRC since January 1988. The AST is an end-to-end high fidelity computer simulation of infrared imaging sensor systems. Existing and candidate flight algorithms are contained in the AST and are modeled at pixel level detail. Actual, alternative, and ideal algorithms are included that perform signal processing, two-dimensional tracking, data association and fusion, three-dimensional tracking, and parameter estimation and report generation. Primary applications to date for the AST have been space-based strategic systems including FEWS / AWS / BSTS, DSP, and MSX.

The purposes of the AST include independent assessment of the performance of system designs, and detailed quantitative analysis of individual design aspects and algorithms. The AST is an ideal tool for high fidelity quantitative performance comparisons between candidate system concepts versus identical scenarios.

The approach taken in developing the AST has been to start with the basics and then expand in both scope and fidelity. Consequently, the AST has been designed with a modular structure to facilitate its development and enhancement. The direction and scope of the improvements made to the AST has been largely determined by those areas deemed to be critical and most in need of in-depth analysis. Improvements have been accomplished in such a manner that the AST has maintained its original modular structure. During this Task 41 phase of development, major changes were made to the AST phenomenological models. These included upgrades to the synthetic background models, development of a statistical persistence model, and development of a target intensity model based on CHARM and SIRRM. In addition, selected AST signal processing and data processing modules were upgraded to accommodate the newly defined phenomenological inputs.

The Advanced Surveillance Testbed, as it exists today, is composed of several components. The functions provided by these components include:

1. target scenario generation,
2. background generation/inclusion,
3. simulation of constellations and orbits,
4. simulation of environmental effects (cloud layer and atmospheric and aspect angle attenuation),
5. sensor and signal processing simulations,
6. two-dimensional tracking algorithms and simulations,
7. data fusion and three-dimensional tracking algorithms and simulations,
8. tactical parameter estimation algorithms and simulations,
9. analysis tools, and
10. graphics support programs.

These components do not necessarily correspond to separate or unique simulations. Rather they give an indication of the range of functions implemented in the AST.

The programs in the AST have, in general, been developed to possess a high degree of fidelity. In developing the programs, trade studies were made to determine to what level functions in the actual system design should be included. Those functions which were found to have an impact on the results produced by a given simulation were included. Those functions which were determined to have only an minor impact on the results produced, but at a large CPU cost, were many times omitted, or designed to be either included or not as desired for the particular test being performed. Since the CPU requirements of the AST could be of concern, the capability for the field-of-view to be restricted to the area(s) of interest is provided in the CPU-intensive programs.

The structure of the Advanced Surveillance Testbed is depicted in Figure 1. This figure shows, at a functional level, those processes performed in the AST and their top-level interrelationships. Some of the analysis tools are stand-alone programs or interact with many of the other programs (such as the graphics programs); consequently their interfaces are not shown.

The flow of data through the AST can be described as follows:

1. Create scenario data appropriate for the current problem under study. This is comprised of two parts: target scenario generation and background generation.

   The target scenario is generated with the set of scenario generation programs which take input describing the desired events and produces a threat scene composed of point source targets in three-dimensional space. These point source targets are then transformed into two-dimensional ideal focal plane returns.

   The option of using background data together with the target data exists. If background data is to be used, the background scene can either be generated with the AST's synthetic background model or the SSGM or be selected from an on-line library of pre-defined background scenes. The raw background scene once created/obtained is then pre-blurred for use in the sensor and signal processing simulations.

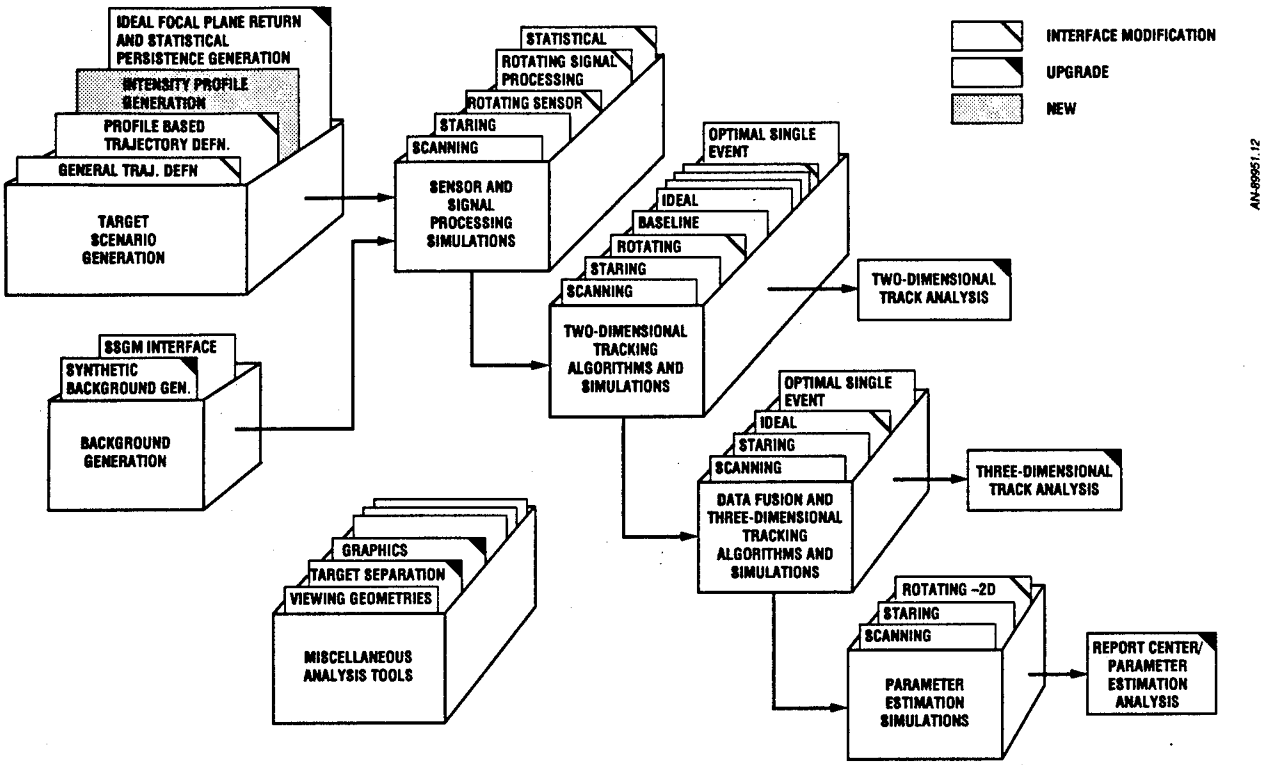

Figure 1. **Advanced Surveillance Testbed Functional Diagram**

2. Produce representative return data. The target scenario data and the pre-blurred background scene (if selected) are then sent through a sensor and signal processing simulation (or set of simulations) which produces representative focal plane data for the sensor and associated signal processing. This resultant data may then be analyzed itself or it may be sent to one of the many tracking algorithms for further processing and analysis.

3. Perform two-dimensional tracking. Output from the sensor/signal processing simulations may then be sent on to one of the two-dimensional tracking algorithms/simulations. These may be either models of a particular system's two-dimensional tracking algorithms, ideal two-dimensional tracking algorithms or the GRC-developed "optimal" two-dimensional tracking algorithm. This resultant data may then be analyzed itself or it may be sent on to either one of the data fusion and three-dimensional tracking algorithms or a tactical parameter estimation algorithm for further processing and analysis.

4. Perform data fusion and three-dimensional tracking. Output from the two-dimensional tracking algorithms/simulations may then be sent on to one of the data fusion and three-dimensional tracking algorithms/simulations. These may be either models of a particular system's data fusion and three-dimensional tracking algorithms, ideal three-dimensional tracking algorithms or the GRC-developed "optimal" three-dimensional tracking algorithm (this last program takes sensor returns directly as input, not two-dimensional tracks). This resultant data may then be analyzed itself or it may be sent on to one of the tactical parameter estimation simulations for further processing and analysis.

5. Perform tactical parameter estimation. The two- and/or three-dimensional tracks may then be input into one of the models of a particular system's tactical parameter estimation algorithm where type, launch time, launch point, launch azimuth and flight azimuth are estimated for each track.

6. Analyze results. Results from various stages of the processing are then analyzed to evaluate performance. Included in this evaluation is the use of the various performance evaluation programs and graphical display tools.

Notice the availability of models of specific system designs and that of ideal and "optimal" algorithms. These models can be used to assess the capability of a selected system's design as a whole as well as individual algorithms under near-ideal situations. The "optimal" tracking algorithms were developed to determine an upper bound for a system's performance with their defined system.

Most programs in the Advanced Surveillance Testbed are written in FORTRAN. The exceptions are some graphics-oriented programs which are written in "C". Currently, the main platform for the AST is a Silicon Graphics (SGI) Crimson Elan. It will run on any SGI machine provided there is sufficient memory available and the proper graphics capability.

3. Task 41 - Advanced Surveillance Testbed Space Based Infrared Upgrades

Existing AST modules were modified under this task to upgrade the Synthetic Background models. A major upgrade was the development of a radiance cloud model based on hexagonal ice crystals that utilizes geometrical optics calculations. Another major upgrade was the development and integration of a Star Catalogue that includes location and spectral intensity data for approximately 500,000 infrared point sources.

New modules were developed of statistical persistence. The model is based on known atmospheric and target trail properties and observed persistence data. Actual DSP observation data was used for tuning and validation.

Additional new modules were developed of target intensity profiles based on the CHARM and SIRRM community standard target intensity models. The new modules allow computation of target intensity profiles for individual target trajectories in user specified spectral bands.

Modifications were made to existing AST signal processing and data processing modules to accommodate these newly defined phenomenological inputs.

Major elements of the AST models include optical and sensor parameters, signal processing, two-dimensional track initiation and extension, data fusion and three-dimensional track initiation and extension, and tactical parameter estimation.

The details of these upgrades are not reported on in this document. The details are contained in other CDRL documents that were previously submitted under this task. These reports are: 1) **The Advanced Surveillance Testbed - Detailed Description Document - Version 5** (CDRL S004), submitted 14 Dec 94, and 2) **Final Briefing - Rome Labs / Harris IRA TOA Task 41 - AST Space Based Infrared Upgrades** (CDRL S003), submitted 14 Dec 94. These reports are Space Based Early Warning System (SBEWS) Competition Sensitive, and as such are subject to limited distribution. Distribution has been limited to Government personnel only at the SBEWS SPO at the Space and Missile System Center in El Segundo, CA, and to Rome Laboratories / IRAE.

4. Acronyms

AST	Advanced Surveillance Testbed
AWS	Advanced Warning System
BMDO	Ballistic Missile Defense Organization
BSTS	Boost Surveillance and Tracking System
CDRL	Contract Data Requirements List
CHARM	Composite High Altitude Radiation Model
COTR	Contracting Officer Technical Representative
CPU	Central Processing Unit
DSP	Defense Support Program
FEWS	Follow-on Early Warning System
GRC	General Research Corporation
IRA/IRAE	Office Symbols of COTR at Rome Laboratories
MSX	Midcourse Space Experiment (BMDO)
SBEWS	Space Based Early Warning Systems
SGI	Silicon Graphics Incorporated
SIRRM	Standardized Infrared Radiation Model
SPO	System Program Office
SSGM	Strategic Scene Generation Model
TOA	Task Ordering Agreement

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